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# **PROPULSION DIRECTORATE**

## **Monthly Accomplishment Report July 2005**

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**SOLAR THERMIONIC TESTING SUCCESSFUL:** On 23 July 2005, a joint AFRL-NASA-General Atomics research team successfully ignited a solar heated thermionic converter. A thermionic power system converts heat energy to electrical energy, and during this testing, the thermionic converter generated 160 amps at 0.2 volts. This is the most electrical power output ever achieved from a single solar heated thermionic converter, and more importantly, this was a very successful “on-sun” demonstration of the Cylindrical Inverted Converter technology that is critical to AFRL’s High-Power, Advanced Low Mass (HPALM) Program. The HPALM concept is a solar energy conversion system for use with spacecraft. The approach involves the use of an inflatable solar concentrator to focus solar energy onto a thermionic converter. This test was conducted at the [NASA Marshall Space Flight Center](#)’s Solar Thermionics Ground Test Facility in Huntsville, Alabama. The results of this test do not represent the ultimate performance because the extremely humid and partly cloudy conditions limited the emitter temperature to a high of 1680 K (~ 2560°F). In better weather conditions, an emitter temperature closer to 2000 K (~ 3140°F) is expected, which translates to a thermionic converter output greater than 100 W. Plans for future tests are still being formulated as better weather conditions may not occur until early autumn. (Dr. S. Adams, AFRL/PRPE, (937) 255-5179)



Panoramic view of the solar heated thermionic converter test site



Close-up views of the test site

**GLOBAL HAWK GENERATOR AND STARTER CHECKOUT SUCCESSFUL:** Functional checkout tests were recently completed for a 270 Vdc, 75-kW generator and a 28 Vdc electric starter mounted onto a Rolls-Royce AE 3007H engine. The tests were the latest milestone of the Range Altitude Power Innovative Technology (RAPIT) advanced demonstrator program coordinated between AFRL’s Propulsion Directorate and the Global Hawk Program Office (ASC/RG). The program goals are to develop Integrated High Performance Turbine Engine

Technology (IHPTET) upgrades and payload power enhancements for the [RQ-4 Global Hawk](#) unmanned aerial vehicle. The generator and starter were built by Innovative Power Solutions (IPS) under Air Force Small Business Innovation Research (SBIR) contracts. The integration with the AE 3007H was accomplished as a team effort between IPS, Allison Advanced Development Company, Rolls-Royce Engines, and AFRL/PR. The 75-kW generator, labeled the LP Generator for its direct-drive by the low-pressure (fan) spool, first demonstrated successful engine-installed operation in 2003 with an AE 3007 engine. The potential benefit of LP spool drive is that it can provide up to 75 kW of power beyond standard HP spool extraction without undue impact to engine operating limits at Global Hawk mission altitudes. Performing the engine runs with the installed LP Generator at Rolls-Royce test facilities provided engine performance calibrations and verified the integrity of the engine drive hardware changes prior to shipping the engine-generator set to Arnold Engineering Development Center (AEDC) for demonstration of LP Generator operation at simulated mission altitudes. The other primary test article, the 28 Vdc



The LP generator



The 28 Vdc starter/generator

starter/generator (S/G), was designed and built by IPS through accelerated execution of a SBIR Phase II contract to allow insertion into the LP Generator test program's schedule. The "brushless DC" S/G design, as a potential replacement of the standard AE 3007 air turbine starter (ATS), can utilize aircraft onboard battery power to provide in-flight engine restart as an added capability, and it can also serve as a backup generator for 28 Vdc aircraft utility power. The S/G successfully demonstrated several engine starts, which were also the first electric starts for this class of turbine engine. With completion of the checkout tests, the LP Generator and S/G are now cleared for testing at AEDC to demonstrate LP power extraction and in-flight engine restart at various simulated altitude/Mach number conditions. (Mr. S. Sepeck, AFRL/PRTP, (937) 255-1466 and Mr. E. Durkin, AFRL/PRPG, (937) 255-6206)

**SUPERCONDUCTING WIRE PRODUCTION SYSTEM OPERATIONAL:** A state-of-the-art, reel-to-reel metal organic chemical vapor deposition (MOCVD) system recently delivered to the Propulsion Directorate's Superconductivity Group is now operational. This system was



developed by [Structured Materials Industries, Inc.](#) under a Missile Defense Agency (MDA) Small Business Innovation Research (SBIR) Phase II grant for multi-kilometer length superconducting wire production. MOCVD is one of the two predominant fabrication methods chosen by industry for economic scaled-up fabrication of long length, high temperature superconducting (HTS) wire. The system will allow the Air Force to provide Cooperative Research and Development Agreement (CRADA) support to industry in the development and optimization of a MOCVD process for continuous production of HTS wire. This capability will also allow the Superconductivity Group to investigate various means of increasing the current carrying capacity of HTS wire by producing thicker films of high quality and transitioning the group's groundbreaking research in the area of magnetic flux pinning to MOCVD processing. Furthermore, the system will provide the Air Force the ability to create long length HTS wire, allowing coil testing to proceed. Such work is essential for the development of power generation systems capable of supporting new technologies such as directed energy weapons, more electric aircraft, and active denial. (2Lt B. Harrison, AFRL/PRPG, (937) 255-6343)

**PR PERSONNEL RECEIVE TWO AFRL CORPORATE AWARDS:** The 6<sup>th</sup> Annual AFRL Corporate Awards Luncheon was held on 14 July 2005 in Albuquerque, New Mexico, and many Propulsion Directorate personnel were honored at the ceremony. The Next Generation Launch



Mr. Mike Huggins led a multi-directorate team that won the Commander's Cup (Team) at the AFRL Corporate Awards

Vehicle Space Vector Team, with representation from the Propulsion, Air Vehicles, Materials & Manufacturing, and Plans and Programs Directorates, won the Commander's Cup (Team) Award. Nine of the 13 members of this team were from AFRL/PR, including the following individuals: Drs. Jean-Luc Cambier and Raymond H. Moszee and Messrs. Michael T. Huggins, Parker L. Buckley, Carl E. Ousley, Glenn W. Liston, Greg B. Bruening, John F. Remen, and Drew DeGeorge. In addition, AFRL/PR's Mr. Robert D. Gregory won the Mission Support (Individual) Award. Given the large number of individuals competing for these awards (more than 5000 across all of AFRL), even being selected as a finalist for an award is a noteworthy achievement, and AFRL/PR personnel were finalists for several other awards. Mr. James S. Cloyd was a finalist for the Commander's Cup (Individual), Capt Adam J. Fink was a finalist for the Leadership Award (Individual), and

Ms. Grace M. Garcia was a finalist for the Administrative Excellence Award (Individual). Furthermore, AFRL/PR personnel were members of three more teams that were finalists for the Commander's Cup (Team) Award. (Mr. J. Pearce, AFRL/PRO (UTC), (937) 255-5015)

**NANOPARTICLE PATENT AWARDED TO SUPERCONDUCTIVITY GROUP:** Drs. Paul Barnes and Timothy Haugan of the Propulsion Directorate's Superconductivity Group were recently awarded [US Patent No. 6,830,776](#), titled "Method of Manufacturing a High Temperature Superconductor." This patent describes a novel method of uniformly dispersing ultrasmall nanoparticles into superconductors to significantly enhance critical current properties in applied magnetic fields. This patent and related work have established industry-leading standards for flux pinning of the YBCO (yttrium barium copper oxide) coated conductor. It is expected that this patented technology can be transferred directly to industry to further enhance the capabilities of the new 2<sup>nd</sup> generation of superconducting wire.



Drs. Timothy Haugan (L) and Paul Barnes (R) were recently awarded a patent related to the manufacture of high temperature superconductors

Improvements in superconducting wire will lead to more compact and efficient power generation systems that have numerous defense and commercial applications. (Dr. T. Haugan, AFRL/PRPG, (937) 255-7163)

**DR. BUNKER NAMED OUTSTANDING YOUNG ALUMNUS:** The Propulsion Directorate's Dr. Christopher E. Bunker was recently named a 2005 Outstanding Young Alumnus by Clemson University. Dr. Bunker, who received his BS in Chemistry from Clemson in 1987, was one of only three individuals to receive this honor for 2005. He was recognized for his efforts to build a strong, viable, and diversified research program in the Fuels Branch (AFRL/PRTG), where he serves as the principal investigator for a team of AFRL researchers and collaborators from seven universities, including his alma mater. Dr. Bunker takes great pride in the fact that his research projects are accomplished largely by student researchers, as one of his goals is to educate and train future PhD candidates. His efforts have been recognized by the Air Force's [Science and Technology Workforce for the 21<sup>st</sup> Century](#) (STW-21) Program, which strives to improve the way the Air Force operates by incorporating university personnel in the AFRL workforce. (Dr. T. Edwards, AFRL/PRTG, (937) 255-3524)

*Want more information?*

❖ A Clemson University article on this award is available [here](#).



Dr. Chris Bunker (far right) is honored as an Outstanding Young Alumnus by Clemson University

NEW IEEE SENIOR MEMBERS: The Propulsion Directorate's Drs. John Horwath and Russell Spyker were recently elevated to the level of [Senior Member](#) in the Institute of Electrical and Electronics Engineers (IEEE). Nominees for the Senior Member grade must have been in professional practice for at least 10 years and shown significant performance. Senior Members



Dr. John Horwath



Dr. Russell Spyker

possess the professional recognition of their peers for technical and professional excellence, and they are eligible to hold executive IEEE volunteer positions. Senior Members are a select group, making up only about 8% of the IEEE membership. The prestigious IEEE Fellows are selected from the ranks of the Senior Members. (Dr. J. Horwath, AFRL/PRPG, (937) 255-9190 and Mr. R. Spyker, AFRL/PRPE, (937) 656-4780)